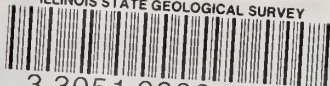


ILLINOIS STATE GEOLOGICAL SURVEY



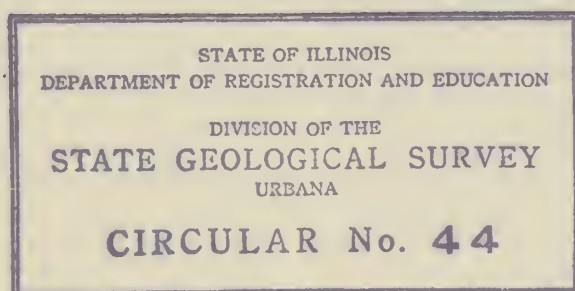
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# Some Problems Related to the Preparation of Illinois Coals


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# Some Problems Related to the Preparation of Illinois Coals<sup>1</sup>

By L. C. McCABE,<sup>2</sup> URBANA, ILL.

The author discusses the mixtures of coal and mineral matter from Illinois mines and relates the problems encountered in cleaning them. He points out the need for and the method of separating the coal and refuse, and discusses the losses encountered in coal separation. Attention is called to the reduction of ash and sulphur and to the enhanced heating value of washed coal, the value of which is difficult to overestimate because of the resultant reduction of fly ash and sulphur fumes during burning. The author states that any effort directed toward the reduction of atmospheric pollution by fly ash and sulphur fumes through the use of better prepared fuel should be encouraged.

COAL preparation in Illinois has long been characterized by good hand picking and screening. In recent years it has come to embrace mechanical cleaning, dedusting, drying, surface treatment by chemicals and oils, and crushing.

The second coal washer in the United States was erected in Illinois in 1870.<sup>3</sup> Development for a number of years was fairly rapid, and in 1908 Illinois ranked first as compared with other coal-producing states in the total amount of washed coal. The washed-coal tonnage increased until 1917 and then rapidly declined until in 1929 only 527,000 tons out of a production of 61,000,000 tons were washed. In 1930 there was a revival of interest in coal cleaning which reached such proportions that in 1936 more than 6,000,000 tons were mechanically cleaned out of a production of 51,000,000 tons. In the period of six years (1930-1936) the amount of washed coal has increased from less than 1 per cent to approximately 12 per cent of the total production. Today there are 21 cleaning plants in operation in the state and three or four awaiting construction. It is probable that when these plants are in full operation, they will produce twelve or fifteen million tons of washed coal annually.

Important factors involved in the trend toward mechanical cleaning are the increased production from mechanized underground workings and from strip mines which do not lend themselves to careful separation of coal and refuse during loading, increased competition from oil and gas, the perfection of mechanical coal-burning equipment with exacting fuel requirements, and the adoption of antismoke ordinances by municipalities.

Selected coals chosen from the producing beds of the State will best illustrate the problems encountered in modern prepara-

tion plants in Illinois and at the same time demonstrate the benefits accruing to the coal consumer.

The modern washery is operated to eliminate noncoal material from the feed entering the plant. Carbonaceous and clay shales from the roof and underclay from the floor of the seam are loaded with the coal to some extent in all mines, but their removal in the cleaning process is relatively simple because their specific gravity is considerably greater than that of the coal. Occasionally, however, clays or shales disintegrate and remain in suspension in the wash water. As a result, the coal in the wash box becomes coated or "whitewashed" and clean-water sprays must be used to remove the coating and give the coal a clean appearance. Where the water supply is limited, as it is in some parts of Illinois, elaborate settling and clarifying systems must be utilized for settling out the suspended solids before the water can again be introduced into the cleaning system.

The bands, lenses, or veins of shale, pyrite, and "bone" which are commonly associated with coal beds may be broken free in mining or may remain attached to the coal. In the latter case the coal adhering to the impurity is frequently wasted unless the washery reject is crushed and recleaned.

Intimate mixtures of coal and mineral matter present the most difficult cleaning problem. This may be illustrated by a comparison of the washability characteristics<sup>4</sup> of two Illinois screenings from mines *A* and *B*, as given in Table 1; such a comparison can also be made from Figs. 1 and 2.

The ash content of the face sample from mine *A* is higher than the average for Illinois and the ash in the sample from mine *B* is considerably lower, but both mines produce raw screenings of about the same ash content. The workings in mine *A* are under a black-slate or a limestone roof and on a bone or a hard clay floor, conditions which permit little introduction of impurities foreign to the coal bed. Mine *B* has a friable shale roof and a soft clay floor, and a considerable quantity of these materials is loaded with the coal.

When cleaned at 1.50 specific gravity, the curves of coal recovery versus ash in Fig. 1 show a recovery of 80.6 per cent for coal *A*, while from Fig. 2, it is 81.6 for coal *B*. The ash content of the former is 9.5 per cent and of the latter 5.0 per cent. The refuse-reject curve shows the refuse from coal *A* to contain only 53.5 per cent ash while the refuse from coal *B* is 73.8 per cent ash. This would indicate a relatively large quantity of combustible matter in the refuse from coal *A*.

The ash-distribution curves best show the extent of the admixture of mineral matter and coal. The gentle warping of the coal-*A* ash-distribution curve, in Fig. 1, is indicative of the dissemination of ash through the coal. The sharp change in direction to the right in the coal-*B* ash-distribution curve in Fig. 2, reflects the presence of the free shale and clay which found its way into the coal during mining.

Separation of coal and refuse is difficult when large quantities of the feed have a specific gravity approaching the effective specific gravity of the separating medium. The  $\pm 0.10$  specific gravity curves of Figs. 1 and 2 show that 15 per cent of coal *A*

<sup>4</sup> Washability Characteristics of Illinois Coal Screenings," by D. R. Mitchell and L. C. McCabe, Illinois Geological Survey, Report of Investigations No. 48, 1937, p. 18.

<sup>1</sup> Published by permission of the Chief, Illinois Geological Survey, Urbana, Ill.

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<sup>3</sup> "Summary Facts on the Coal Resources and Coal Industry of Illinois," in collaboration with the Engineering Experiment Station, University of Illinois. State of Illinois Geological Survey Division, Urbana, Ill., 1935.

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NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

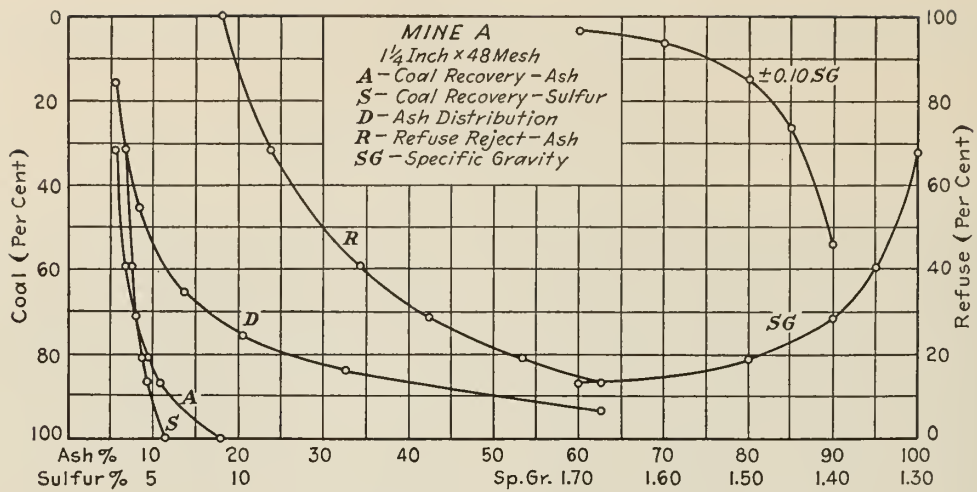


FIG. 1 WASHABILITY CHARACTERISTICS OF COAL FROM MINE A

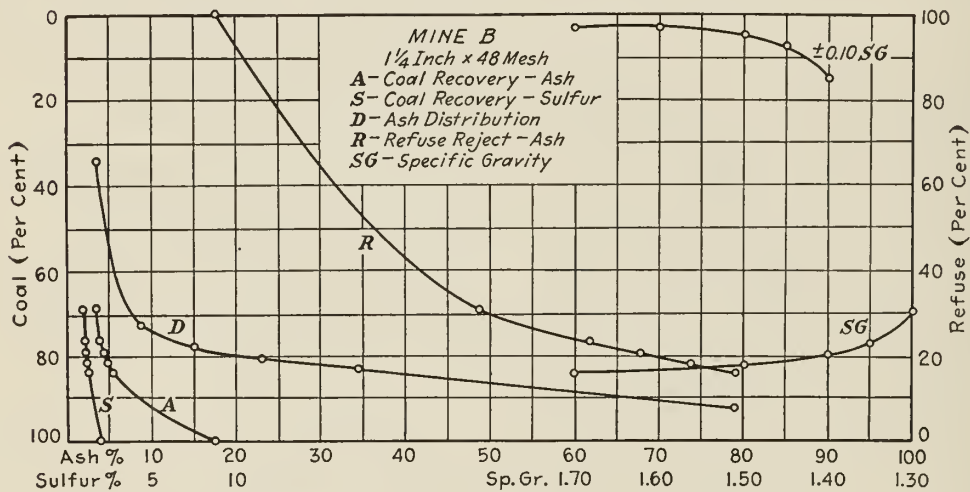


FIG. 2 WASHABILITY CHARACTERISTICS OF COAL FROM MINE B

and only 4.3 per cent of coal *B* is between 1.40 and 1.60 specific gravity. Because of the large quantity of material having a specific gravity near the separating gravity, coal *A* is a difficult coal to clean while coal *B*, with a relatively small amount of material of about 1.50 specific gravity, presents a simple cleaning problem. The use of specific-gravity-distribution curves makes it possible to select a specific gravity at which washing can be done most efficiently. Furthermore, they show that the possibility of efficient operation at one specific gravity does not assure similar efficiency at another.

Occasionally, in spite of a knowledge of the washability characteristics of the coal, considerations other than efficiency may direct the operation of a cleaning plant. The consumer, frequently without discrimination, objects to dull or slabby coal and to meet this objection a plant will operate to reject such coal, although it has a high calorific value. Sales departments may find that a washed coal having 7.1 per cent ash would be more readily marketed if the ash is reduced to 6.8 per cent. To obtain this reduction of 0.3 per cent in ash 1 or 2 per cent of coal may find its way into the washery reject.

For numerous reasons the tonnage losses in cleaning are relatively high. At some mines the feed may shrink 20 per cent or more in passing through the preparation plant. While the reject may contain little or no coal, it represents tonnage that formerly found its way into the market and must therefore be compen-

TABLE 1 COMPARISON<sup>a</sup> OF RECOVERY, ASH AND SULPHUR PERCENTAGES IN COALS FROM TWO ILLINOIS MINES

Mine	Ash		Coal re-covery	Float ash	Float sulphur	Sink ash	Sink sulphur
	Face sample	Un-washed screenings					
A	10.6	18.0	80.6	9.5	4.4	53.5	11.4
B	6.5	17.6	81.6	5.0	1.2	73.8	5.4

<sup>a</sup> Based on 1 1/4-in. to 48-mesh coal, dry basis, with 1.50 specific gravity

sated for by increased price or expanded sales of washed coal.

Wet-washing plants cannot effectively clean coal smaller than 48 mesh. In some instances it is removed from the larger coal by dedusting or by screening, but the most common practice in wet-washing plants is to remove it from the system with a thickener or centrifuge, or to permit it to escape to the settling pond.

The ash content of dusts from ten Illinois coals<sup>4</sup> recently studied ranged between 15 and 37 per cent ash. There is no ready market for such material and with few exceptions it is a waste product. It constitutes as much as 5 per cent of the tonnage in some mines.

In addition to tonnage losses, washing entails the loss of potential heat in the washery refuse. That the percentage of heat loss is not as great as the percentage of tonnage loss is apparent from Table 2, which gives a comparison of two coals in the unwashed and in the washed condition. The washability characteristics of coal from mines *C* and *D* are shown in Figs. 3 and 4,



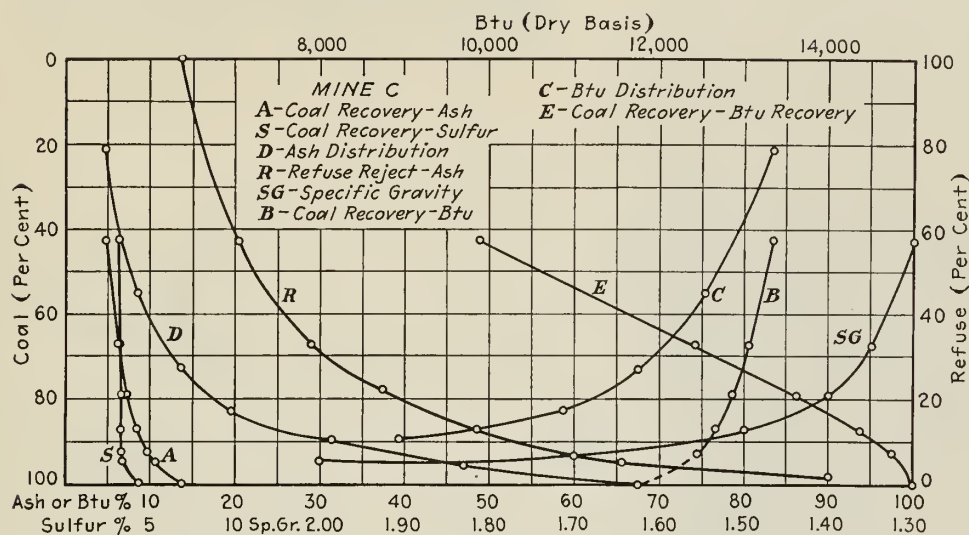


FIG. 3 WASHABILITY CHARACTERISTICS OF COAL FROM MINE C

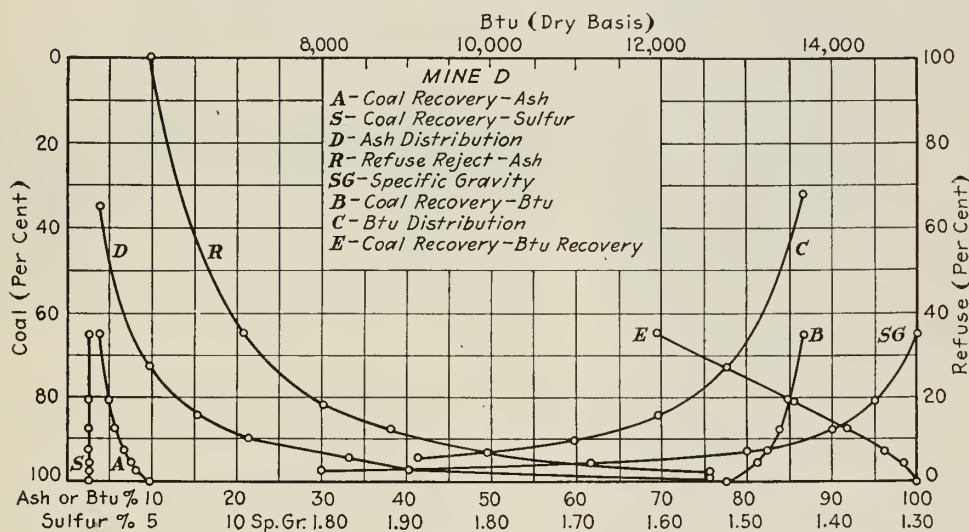


FIG. 4 WASHABILITY CHARACTERISTICS OF COAL FROM MINE D

TABLE 2 COMPARISON ON A DRY BASIS OF WASHED AND UNWASHED COALS FROM TWO ILLINOIS COAL MINES

Mine	Coal recovery, per cent	Ash, per cent	Sulphur, per cent	Heat value, Btu per lb	Btu recovered, per cent	Btu increase, per cent
C	100	13.62	4.5	11,756	100	...
	90	9.00	3.1	12,580	96	7.0
D	100	9.85	1.2	12,743	100	...
	90	6.50	1.0	13,300	94	4.4

respectively. When washed for a tonnage recovery of 90 per cent, 96 per cent of the Btu value is recovered in coal C and 94 per cent in coal D. The greater part of these losses of potential energy may be accounted for by the low calorific value of "bony" coal and pyrite which, in part, constitute the refuse.

Because of the reduction of its ash and sulphur content, a coal is enhanced in its calorific value by washing. Coal C, containing 13.6 per cent ash, 4.5 per cent sulphur, and 11,756 Btu per lb, as it comes from the mine, may be washed at 90 per cent recovery to produce a fuel with 9 per cent ash, 3.1 per cent sulphur, and 12,580 Btu per lb. Changes in the character of coal as a result of washing which are of interest to the consumer are 31 per cent reduction of sulphur, 34 per cent reduction of the ash percentage, and 7 per cent increase in calorific value. Coal D does not offer comparisons of the same magnitude because it has relatively

low ash and sulphur content as it is mined. However, the heat value is raised from 12,743 to 13,300 Btu per lb by washing.

A discussion of the problems related to the preparation of Illinois coals would not be complete without some consideration of the distribution and varieties of sulphur<sup>5</sup> and their reaction to the cleaning process.

Sulphate, pyritic, and organic sulphur are the three varieties generally recognized. The sulphate form is thought to represent mainly the gypsum in the coal, but as the amount is usually less than 0.25 per cent it will be ignored in this discussion. Because of its yellow color, metallic appearance, and high specific gravity (4.95-5.1), pyrite is the most easily identified of the forms of sulphur. Organic sulphur is that part of the total sulphur which is neither chemically determined sulphate sulphur nor chemically determined pyritic sulphur.

The total sulphur content of most Illinois coals is high, averaging 4.37 per cent on an ash-and-moisture-free basis (3.4 per cent on the as-received basis). Fig. 5 shows the distribution of total sulphur, and Fig. 6 shows the minimum and maximum values for

<sup>5</sup> "Distribution of Sulfur in Illinois Coals and Its Geological Implications," by G. H. Cady, Illinois Geological Survey, Report of Investigations No. 35, 1935.

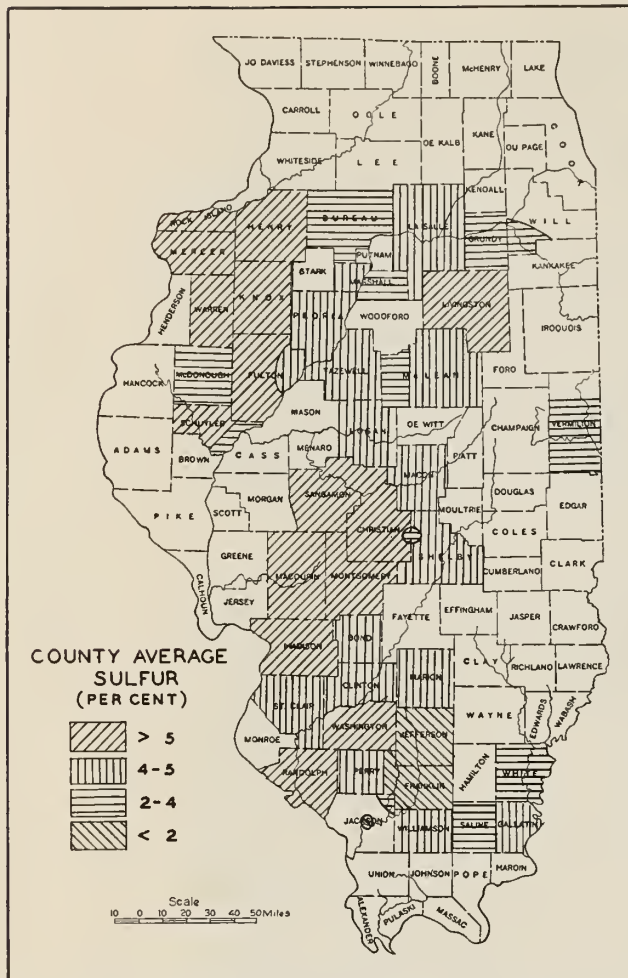


FIG. 5 COUNTY AVERAGE OF SULPHUR CONTAINED IN FACE SAMPLES OF ILLINOIS COALS ON AN ASH-AND-MOISTURE-FREE BASIS

organic sulphur in the coal in various counties in the state,<sup>6</sup> information that is particularly useful in evaluating the possibility of sulphur removal by washing. The data for mapping sulphur distribution are from face samples and Cady<sup>7</sup> has pointed out that they do not tell the whole story in regard to the amount of pyritic sulphur present in the coal as more or less pyrite is discarded in collecting face samples. He concludes that the amount of pyrite discarded, if included in the face sample, would rarely increase the sulphur more than 2 per cent and commonly not more than 1 per cent. For practical consideration in pyrite reduction the amount of discarded pyrite need not be of concern as its specific gravity is so much greater than the coal that it is not involved in the economic limits of sulphur reduction.

There appears to be no reduction in the amount of organic sulphur in the washing process and in theory, should the pyritic sulphur be so concentrated as to be broken free in mining, and discarded in toto with the reject, the organic sulphur would represent the irreducible minimum of sulphur content. Actually it is

<sup>6</sup> "Distribution of Sulfur in Illinois Coals and Its Geological Implications," by G. H. Cady, Illinois Geological Survey, Report of Investigations No. 35, 1935, pp. 24 and 28.

<sup>7</sup> Ibid., p. 26.

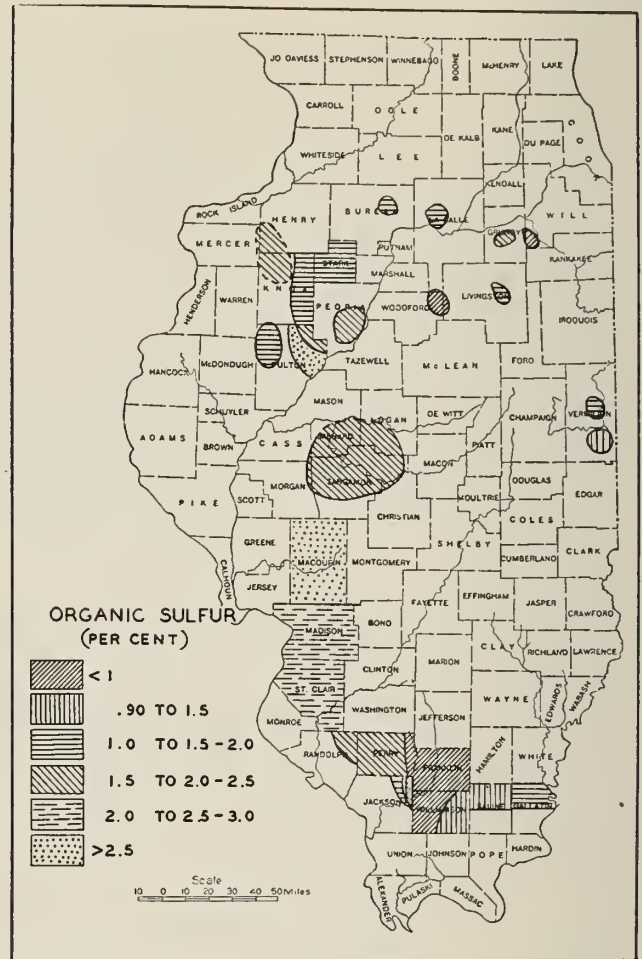


FIG. 6 MINIMUM AND MAXIMUM PERCENTAGES OF ORGANIC SULPHUR IN COAL FROM VARIOUS COUNTIES IN ILLINOIS

not possible to remove all the pyritic sulphur, for much of it is disseminated through the coal in particles of microscopic size. In the high-sulphur coals, 15 to 35 per cent of the total sulphur may be removed by washing, but the low-sulphur coals are little affected, as shown for coal *D* in Fig. 4.

It was entirely relevant in discussing the problems of preparation to call attention to the magnitude of sulphur and ash reduction and to the enhanced heat value of washed coal. Greater fuel uniformity, less ashes, dust, and sulphur vapors are important corollaries. It would be difficult to overestimate the value to a municipality of the effective reduction of fly ash and sulphur fumes which can be brought about by the use of clean coal. Any effort directed toward reduction of atmospheric pollution by fly ash and sulphur fumes through the use of better prepared fuel should be encouraged because it is based on sound scientific premises.

Illinois coals can and are being burned smokelessly in equipment designed to raise the volatile matter to its ignition temperature before it passes into the stack. For the great number of domestic furnaces not particularly designed for the burning of high-volatile coals, installation of a conversion burner or stoker, or change to a processed coal appears to offer the only solution of the smoke problem without substitution of more expensive oil or gas.



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